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SmartLab: Automated Coding Laboratory System

Kartik R Patil, Prof. Gunasekaran K

Department of MCA, AMC Engineering College, Bengaluru, India

Assistant Professor, Department of MCA, AMC Engineering College, Bengaluru, India

ABSTRACT: This paper presents the design and development of **SmartLab**, an automated coding laboratory system aimed at streamlining curriculum management, enhancing student learning through scaffolding, and removing infrastructure barriers. The proposed system enhances traditional Learning Management Systems (LMS) by integrating advanced tools such as **Generative, Optical Character Recognition**, and a **5-Level Progressive Learning Module**. The development model follows a structured approach including requirement analysis, database architecture, API integration, and user interface design. The extended functionalities demonstrate improved faculty efficiency and provide coding environment.

KEYWORDS: Automated Lab, Generative AI, Curriculum Scaffolding, Cloud LMS, OCR, Code Evaluation.

I. INTRODUCTION

Computer programming laboratories are essential for technical education, serving as the practical ground for applying theoretical concepts. However, with evolving educational standards, there is a need for advanced systems. This paper discusses the design and development of SmartLab, a system that automates the generation of problem sets from raw syllabus data, provides intelligent code feedback, and supports faculty with real-time progress tracking.

II. LITERATURE REVIEW

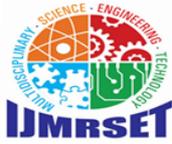
Previous research studies focus on e-learning platforms, automated grading, and static code analysis. Systems like Moodle or Google Classroom facilitate file management but lack deep pedagogical intelligence. Several authors highlight the importance of "scaffolding"—breaking complex tasks into smaller steps—to improve student retention. This study builds on these concepts to create SmartLab, which uses AI to dynamically generate scaffolded content.

III. PROBLEM STATEMENT

Traditional laboratory management lacks advanced control for personalization, instant feedback, and automated content generation. There is no integrated system that instantly converts a syllabus PDF into a structured coding course or provides AI-driven logic correction without heavy local compilers. Hence, a solution is required to design and implement additional functionalities that improve the practical learning experience.

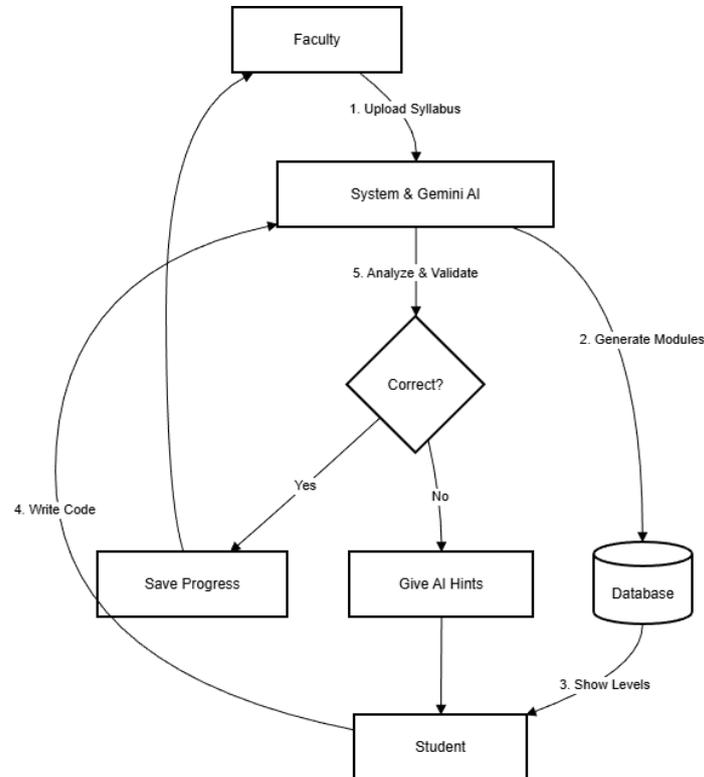
Objectives

- To design and implement an automated "Smart Lookup" engine for syllabus parsing.
- To integrate AI-based tools to generate "5-Level Progressive" problem sets.
- To enhance accessibility by removing the need for local compiler installations.
- To provide a real-time analytics dashboard for faculty to monitor student progress.



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Tools and Technologies Used

Frontend: HTML5, CSS3, JavaScript (Monaco Editor for IDE).

- Backend: PHP (running on Apache).
- Database: MySQL (Relational data storage).
- AI/ML: Google Gemini API (Content Gen & Logic Check), OCR.space API (Image Text Extraction).
- Deployment: Local Hosting.

Algorithms Used in Extended Instagram Functionalities

1. Content Generation Algorithms Used for converting raw syllabus keywords into structured lab manuals.

- Few-Shot Prompting (LLM): Instructs the AI to act as a professor and output strictly structured JSON data (Level 1 to Level 5) based on a single input keyword.
- Contextual Parsing: Extracts specific topics (e.g., "Linked Lists") from large PDF blobs using regex patterns before sending them to the AI.

2. Optical Character Recognition (OCR) Algorithms Used for reading syllabus screenshots or scanned images.

- Text Detection & Extraction: Utilizes API-based OCR to identify text blocks within an image file uploaded by the faculty.
- Noise Reduction: Post-processing scripts clean the OCR output (removing non-alphanumeric characters) to ensure the AI receives clean prompts.

3. Code Evaluation Algorithms

Used to check student submissions without a local compiler.

- Semantic Code Analysis:

Instead of simple syntax checking, the system uses the Gemini model to analyze the logic of the code.

- Example: "Does this loop correctly calculate the Fibonacci sequence?"

- Error Explanation:



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If the code fails, the algorithm generates a human-readable explanation of the error rather than a cryptic compiler code (e.g., "You missed a semicolon on line 5").

4. Scaffolding Logic Algorithm

Used to control user progression.

- **Progressive Unlocking:**

The system employs a rule-based algorithm where Level N+1 remains locked until Level N passes the "Success" state in the database.

- **Difficulty Scaling:**

The AI dynamically adjusts the complexity of the generated questions based on the "Level" parameter sent in the API request.

IV. RESULT AND ANALYSIS

The extended SmartLab functionalities significantly enhance faculty convenience and student engagement.

- **Time Efficiency:** The AI-based content suggestions reduce lab setup time from hours to seconds.
- **Learning Impact:** The 5-Level system ensures beginners are not overwhelmed, categorizing problems into "Warm-up," "Syllabus," and "Advanced" tiers.
- **Analytics:** The dashboard provides insights into which specific concepts students are struggling with based on error logs.

V. CONCLUSION

The proposed SmartLab system successfully addresses the limitations of traditional manual laboratory management. By integrating smart algorithms, cloud-based compilers, and automated content generation, the system offers a more personalized and efficient educational experience. Future work may include integrating voice-based coding assistance and plagiarism detection models.

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